Applications of the Pythagorean Theorem - Magnetism.

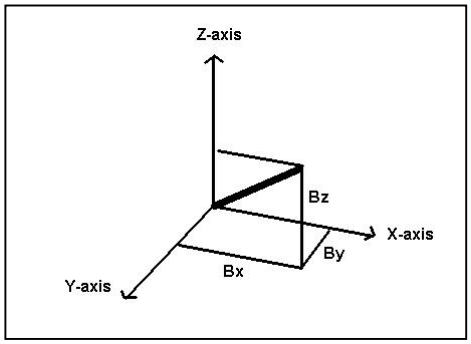
Unlike temperature, magnetism requires three numbers to define the strength of its field in space. Scientists call magnetism a **Vector** quantity because it is defined by both its magnitude at a point in space, and its direction at that point, given by the coordinate (X, Y, Z). The Pythagorean Theorem is used to calculate the magnitude (or total strength) of the magnetic field from the separate Bx, By and Bz quantities that make up its description as a field in 3-dimensional space. To find the Bx, By and Bz components of Earth's magnetic field (in units of nanoTeslas, nT) where you live, visit the International Geomagnetic Reference Field Model (Part 2 Form)

http://nssdc.gsfc.nasa.gov/space/model/models/igrf.html

Enter the year (2004) and the requested geographic latitude, longitude (in degrees, minutes and seconds – D M S entries in table) and elevation (Use 0.0 km for table). You can find the geographic coordinates for a specific location at

http://geonames.usgs.gov

Follow 'Query GNIS" to the input form. Select 'Civil' for a town name.



The Pythagorean Theorem in 3-dimensions is →

$$D = \sqrt{x^2 + y^2 + z^2}$$

Use the Pythagorean Theorem to fill-in the last column of the table

City	Longitude D M S	Latitude D M S	Bx (nT)	By (nT)	Bz (nT)	Total B (nT)
Chicago	87 54 55	41 50 05	26600	1234	48620	**55434**
Boston	71 05 00	42 18 00	25251	2234	46676	
Miami	80 32 00	25 37 00	36274	0.2	28396	
Hollywood	118 20 00	34 01 00	32161	-2684	39236	
Bangor	68 47 15	44 49 56	23437	2600	48244	
Kansas City	94 43 37	39 07 06	28846	365	46535	
Sioux Falls	96 43 48	43 32 48	25602	283	50988	
Spokane	117 22 00	47 37 00	22977	-3263	53054	
Provo	103 52 06	43 10 02	26045	-875	50767	
Anchorage	149 15 02	61 10 00	16377	-3572	53739	
Honolulu	154 53 24	19 33 15	32644	1402	14594	
Sedona	111 47 35	34 50 38	31818	-1978	41379	

Question 1 - What cities have the highest and lowest magnetic field (**B**) strengths?

Question 2 - What is the average **B** value of Earth's magnetic field for all locations?

Question 3 – Some adults think that Sedona Arizona has special 'powers'. How does the magnetism at this location compare to other locations in the table?

Question 4: Plot the **By** values on a map. What pattern do you see?

City	Longitude D M S	Latitude D M S	Bx (nT)	By (nT)	Bz (nT)	Total B (nT)
Chicago	87 54 55	41 50 05	26600	1234	48620	**55434**
Boston	71 05 00	42 18 00	25251	2234	46676	75116
Miami	80 32 00	25 37 00	36274	0.2	28396	65148
Hollywood	118 20 00	34 01 00	32161	-2684	39236	71847
Bangor	68 47 15	44 49 56	23437	2600	48244	75941
Kansas City	94 43 37	39 07 06	28846	365	46535	77430
Sioux Falls	96 43 48	43 32 48	25602	283	50988	80688
Spokane	117 22 00	47 37 00	22977	-3263	53054	81894
Provo	103 52 06	43 10 02	26045	-875	50767	80701
Anchorage	149 15 02	61 10 00	16377	-3572	53739	79609
Honolulu	154 53 24	19 33 15	32644	1402	14594	50607
Sedona	111 47 35	34 50 38	31818	-1978	41379	73871

Question 1 - What cities have the highest and lowest magnetic field (**B**) strengths?
Answer: The city with the highest total magnetic field strength is Spokane, Washington (81894 nT). The city with the smallest total magnetic field strength is Honolulu, Hawaii (50607 nT)

Question 2 - What is the average **B** value of Earth's magnetic field for all locations?
Answer : (55434 + 75116 + 65148 + 71847 + 75941 + 77430 + 80688 + 81894 + 80701 + 79609 + 50607 + 73871) / 12 = 868286/12 = **72357 nT**
Remember to have the students give the answer in the correct physical units.

Question 3 – Some adults think that Sedona Arizona has special 'powers'. How does the magnetism at this location compare to other locations in the table?
Answer: There are several things the student can note. 1) It has only the 8th strongest magnetic field out of 12 cities; 2) It has the third lowest Bz value (41379 nT); and 3) It has the fourth-lowest By value (-1978). None of these are as remarkable as what we find among the other large cities in this random sample.

Question 4: Plot the **By** values on a map. What pattern do you see?
Answer: The most obvious thing the students should notice is that:
1) The By magnetic values are always much smaller than for the Bx and Bz magnetic components. In fact they are typically only about 10% of the other two components;
2) The values to the east of latitude 100 to 105 degrees are positive. The values to the west are negative. **Note, the reason for this is that the longitude of the magnetic pole is 105 degrees, so this is the 'axis of symmetry' for these values.**